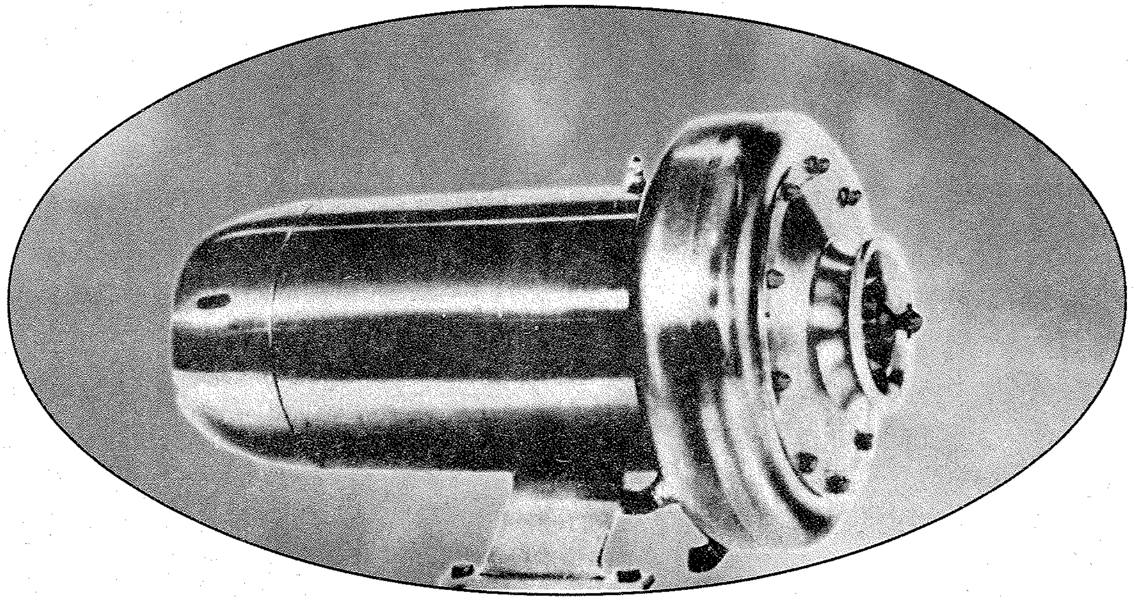
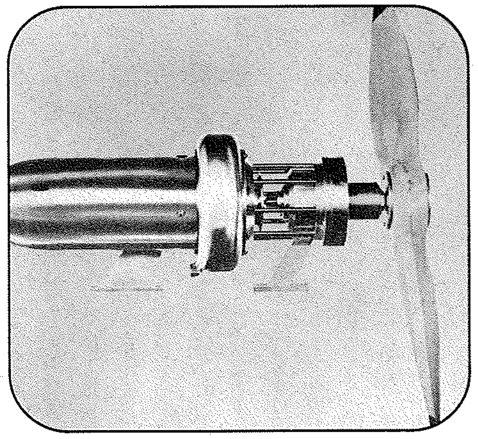
# The Daemon

## Build this powerful turbojet engine in an ordinary home shop!

- *Produces up to 30 horsepower!*
- *Powers a wide variety of land, air and sea vehicles!*



The completed Daemon Turbojet Engine



The Daemon Turbojet Engine with a speed-reduction drive

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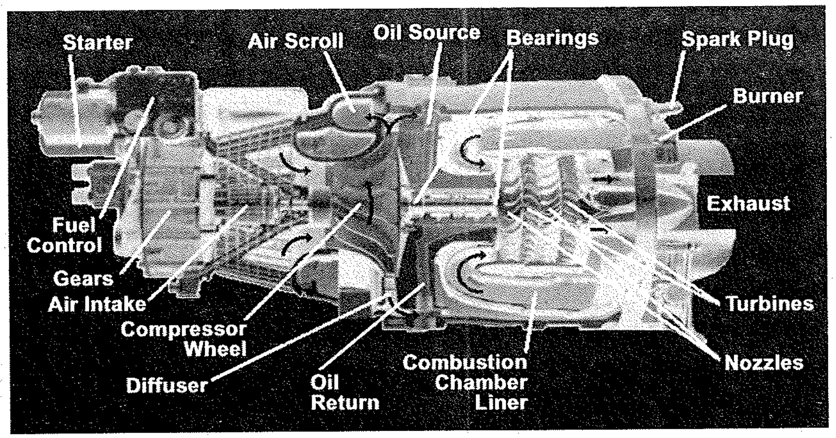
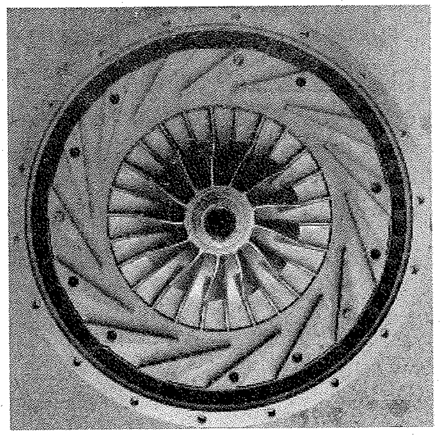
USA

# HOW SMALL GAS TURBINE ENGINES WORK



Cutaway of turbojet engine



Compressor wheel

Illustrated above is a typical small gas turbojet. Air is drawn into the engine through a protective grill to a rotating impeller which, with a ring of stationary vanes called the "diffuser," forms the compressor of the engine. Curved vanes at the intake, the rotating inlet vanes, guide the air into the impeller. As the air passes through the compressor it is accelerated outwards at high speed, but slowed down in the diffuser. Additional vanes are sometimes used to curve the air flow around a 90 degree bend into the combustion chamber. The air pressure rises to as much as four times atmospheric and is consequently heated. A portion of the air flow from the compressor is collected and released from the engine. The stream of air produced is quite powerful and is sometimes used to drive "cold" turbines to attain rotary horsepower via its shaft. The air pressure is moderate, but the mass flow is quite high. Valves or venturis are fitted to keep the engine's air flow within pre-determined limits. Compressors are usually made of aluminum, coated to reduce corrosion. For the sake of durability, the rotating inlet guide vanes may be made of steel; or the entire wheel may be made of titanium.

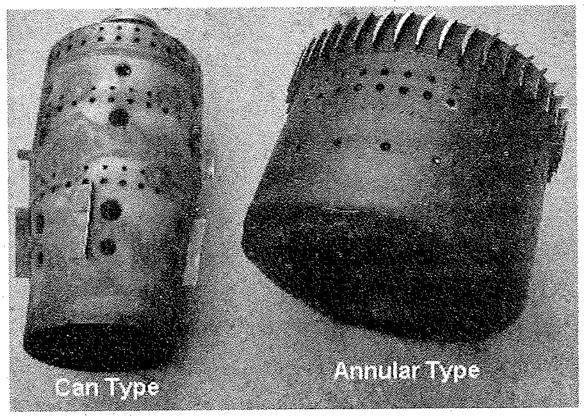
Power for the gas turbine engine is obtained by burning fuel in its combustion chamber; the air flowing through the engine is thus heated, causing it to expand and gain kinetic energy. Combustion chamber designs vary, but their operation is the same. A flame is maintained in a metal liner within the engine by air metered in through holes and orifices. Fuel sprayed into the combustion chamber burns continuously once ignited. Holes in the metal liner determine the air distribution throughout the combustion chamber. Perhaps a fourth of the air passing through the engine is burned, the rest mixed with the exhaust, lowering its temperature so it can pass through the turbine.

There are two basic types of combustion chamber: the can type and annular type. The can type is simply a canlike structure mounted on one side of the engine. A burner at one end feeds the fuel into it. Heat-resistant ducting guides the combustion gases from the chamber to the turbine nozzle. In some cases two combustion chambers are mounted on either side of the engine. The annular-type combustion chamber surrounds the engine's axis and takes the form of a cylinder or cylindrical disc in shape. The exhaust gases from several burners at one end are guided onto the turbine nozzle. Gas turbine engines built around annular combustion chambers are usually smaller.

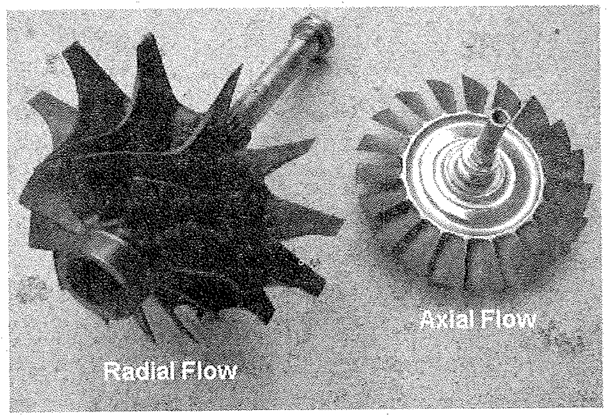
Fuel flow to the combustion chamber is controlled by a mechanical or electronic governor. The hot gases generated by the combustion process drive one or more turbine wheels, which drives the engine's compressor and can also be used to drive an external device. A single shaft interconnects the turbine, compressor and device. At least one turbine is always required to drive the compressor, while a second mechanically independent turbine can be used to drive the load, in which case the engine would be equipped with two shafts. About two thirds of the mechanical power developed is used to drive the compressor.

Two types of turbine are found in small gas turbines. A radial inflow wheel is constructed in a similar way to a compressor but is made of heat resistant steel, usually Nimonic. Hot gases from the combustion chamber are directed inward by a nozzle ring and tangentially onto the radial blades of the turbine wheel. The gases flow inward and then along the axis of the wheel and out through an exhaust duct. The radial flow turbine is commonplace in turbo-chargers and is both more efficient than a single axial wheel and more tolerant of larger mechanical clearances. The disadvantage is that their typical single-piece construction limits their size. Only one radial inflow stage is possible.

*Axial* is the second type of turbine wheel. Like in larger engines a disc is fitted with airfoil sections around its circumference. Hot gases are directed onto them from the combustion chamber by a ring of similar, but static blades which form a nozzle ring. The turbine disc and nozzle are made of a heat resistant steel such as Nimonic. Axial flow turbines can be assembled in multiple stages while small gas turbines normally have a maximum of two. Turbines and nozzle assemblies get very hot and air from the compressor is usually arranged to flow over these components to help cool them.



Combustion chambers



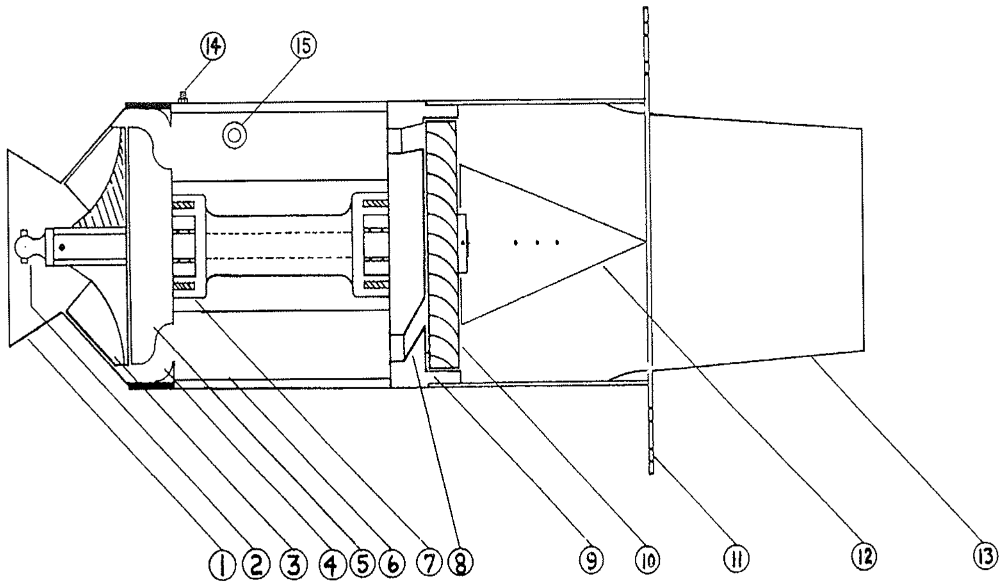
Turbine wheels

Small twin shaft gas turbines are less common than single shaft engines. A single shaft engine normally drives a load via a reduction gearbox; the same gearbox may also drive engine accessories such as fuel and oil pumps. A typical load may be an electrical generator, mechanical pump, a second air compressor, etc. A single-shaft engine usually must be accelerated to operating speed before it can accept a load, and normally the load should be removed before it is shut down. Twin- shaft gas turbines can, on the other hand, be started with a mechanical load applied.

Small gas turbines are usually lubricated by oil sprayed from small jets onto the ball bearings inside the engine. A pressure pump with a relief valve pressurizes the system feeding the jets. The circulating oil becomes hot and is normally passed through some sort of cooling device, such as a fan- cooled or intake- mounted radiator. The oil pump is normally driven by the engine via a train of gears or a separate electric motor.

Small gas turbines are started by electric motors or sometimes by hydraulic, handcrank and pull-cord starters. Most gas turbines self-sustain at about 25-30% of their rated speed—the self sustaining point being when the compressor begins to develop significant gauge pressure.

The ignition of small gas turbines is most commonly by the discharge into a sparkplug of a capacitor that has been charged to about 3000 volts. A special, sealed gap breaks down when the capacitor is fully charged and fires the engine-mounted spark plug. The spark plug is mounted so that it protrudes into the combustion chamber and is placed close to the spray coming from the fuel nozzles. A cold engine may be difficult to start. On hand started engines there is no electrical power to operate the ignition system, so a small generator or magneto is required to generate a spark.



## HOW *THE DAEMON* OPERATES

Shown above is a simplified turbojet engine *similar* to *The Daemon. The Daemon* Turbojet engine consists basically of a centrifugal air compressor (Item 3) and a single-stage gas turbine (10). The compressor is made up of a housing, an impeller and a diffuser. The compressor-impeller (3) is coupled to the turbine by a shaft and bearing assembly (7). The turbine is driven by the combustion of a hydrocarbon (gasoline or alcohol) mixed with air in the combustion chamber (6), which receives the air/gas mixture from the compressor (3), through the air passages (4). *The Daemon* also uses an oil-circulating system that both lubricates and helps cool the bearings. Atmospheric air enters via the compressor/impeller shroud (1) into the multi-vaned impeller (3). Gasoline or alcohol, injected through the fuel valve (14), is sprayed through a group of nozzles mounted behind the diffuser (5) into the combustion chamber (6). The spark plug ignites the air/gas mixture (15) in the combustion chamber (6). The expanding exhaust gases leave the combustion chamber (6) and pass through jet nozzles (8) to the turbine wheel (10). The energy of this exhaust gas passing through the turbine turns the shaft within the bearing assembly (7) and the impeller blades (3), in turn powering the compressor. The force of the rotating turbine shaft provides usable torque (horsepower). The exhaust gas leaves the turbine wheel (10), exhaust cone (12), and finally exits through the exhaust tube (13). The force of the exiting exhaust gas from the exhaust tube creates jet thrust. Thrust increases as jet velocity and air-mass flow is increased. Both are largely determined by the amount of fuel burned. The more fuel burned, the greater the thrust of propulsion.

## STARTING AND OPERATING *THE DAEMON* TURBOJET

*The Daemon* Tubojet engine can run on regular gasoline, general aviation type white gasoline, or various types of commercial alcohols. However, fuels such as isopropyl, methyl and ethyl alcohol develop extreme heat in turbojet engines. Alcohols do produce the greatest amount of static thrust and can be considered good fuels *if* certain chemical coolants, such as menthol, are blended in. This alcohol-coolant mixture will produce a very satisfactory, cool-running turbojet fuel.

Both pressurized and gravity type fuel systems may be used to operate *The Daemon*. The simpler gravity fuel system works very well; however, since the amount of fuel ejected into the engine and the maximum RPM/thrust are in proportion, the pressure-fuel system, with the fuel tank pressurized to about 30 to 40 lbs., would provide the greatest power. *The Daemon's* thrust can be precisely controlled by a needle-valve throttle. The needle valve is placed somewhere between the fuel tank and fuel intake valve on the engine. For radio-controlled applications, a servomotor could adjust the valve for smooth control of the turbojet. A low-volume oil pump lubricates the engine via the oil intake fitting.

*The Daemon* may be started by one of two methods. However, *before attempting to start the engine make absolutely certain that the engine is securely bolted down in an outdoor setting and that all safety precautions have been adhered to!*

In method #1, a small electric motor—such as an electric drill or even a small 6 to 12 volt automobile heater motor—is used as a starter. A quick connect-disconnect female coupling that matches the male ball coupling on *The Daemon* (item #2 on the above drawing or part #31 on pages 4, 5 & 8) is attached to the starter's shaft. The starter's coupling would consist of a short section of tubing with a 3/32" slot that just slides over The *Daemon's* coupler (part #31) and pin (part #32). The oil pump is started, then the starter motor. When the compressor and turbine are rotating at between 8,000 and 10,000 RPM, the throttle valve is opened and the spark plug is energized momentarily (via an ignition coil attached to a motorcycle or car battery). The engine should start immediately. The starter motor can then be backed off of the engine's coupler.

Starting method #2 uses compressed air stored in a tank. The tank must have a valve equal to 3/4" pipe and to this is connected a length of hose (rubber garden type is fine) with a rubber cup on the other end, which will be held to the front of the engine's compressor shroud. The engine's oil pump is started, then the air is turned on, causing the turbine to spin to starting RPM, at which time the throttle is opened and spark plug energized. A large Army surplus oxygen tank would provide about two or three startings.

**SPECIFICATIONS OF *The Dæmon***

| | |
|---|---|
| **LENGTH** | 15.75 inches |
| **MAXIMUM DIAMETER** | 8.5 inches |
| **WEIGHT** | 15 lbs. |
| **TYPE OF FUEL** | Gasoline, Alcohol |
| **FUEL CONSUMPTION** | 4.5 gallons per hour |
| **COMPRESSOR TYPE** | Centrifugal |
| **REVOLUTIONS PER MINUTE (MAX.)** | 49,000 |
| **PRESSURE RATIO** | 2:1 design point |
| **GAS INDUCTED** | 0.5 pound per second |
| **TURBINE TYPE** | Impulse |
| **THRUST** | 15 (static) to about 25 lbs. (dynamic) |
| **POWER OUTPUT @ SHAFT** | 30 horsepower (max.) |

**ENGINE RPM TEST CHART**

**Alcohol**

| | Flame-out | Starting | Low Range | High Range |
|---|---|---|---|---|
| **RPM** | 8,300 | 8,000 to 10,000 | 9,000 | 49,000 |

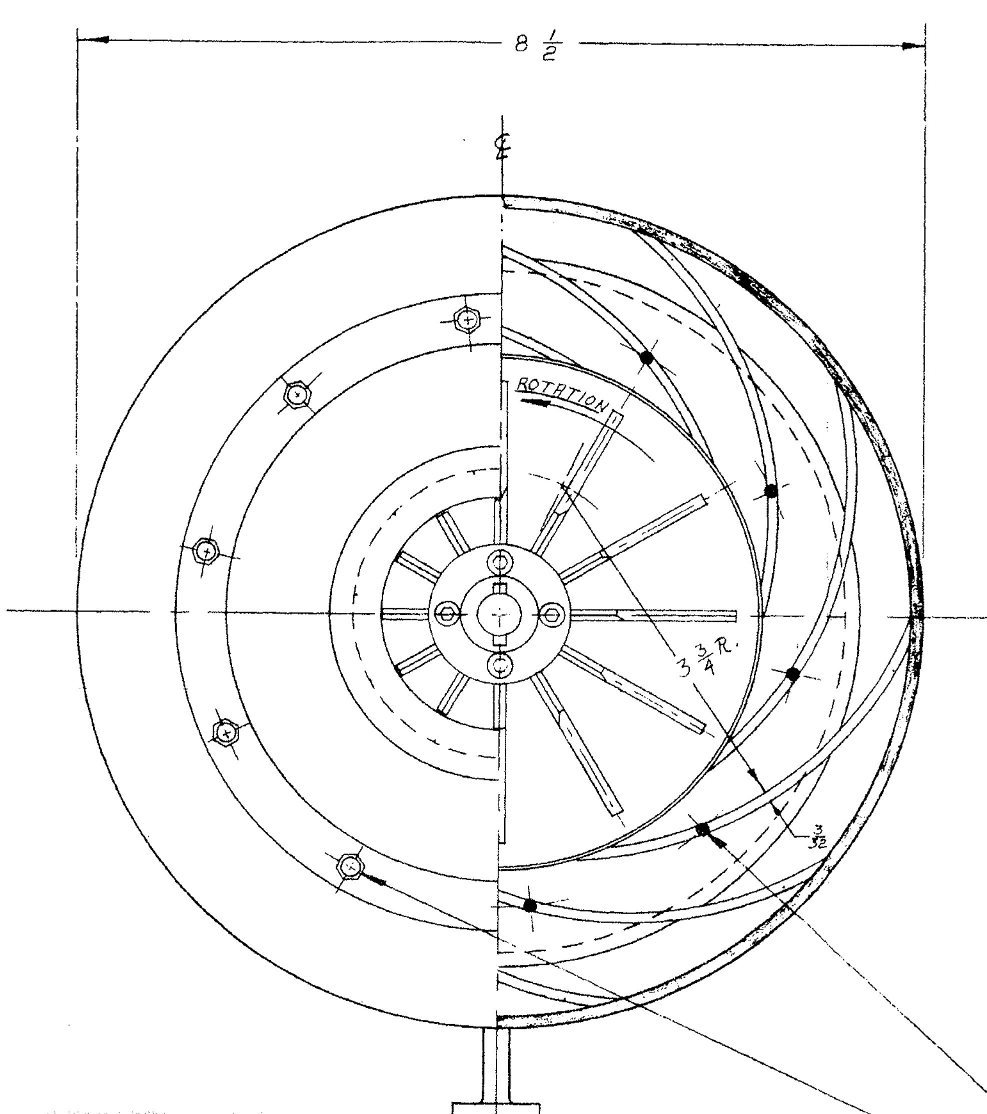
*Exhaust temperature: 1100 degrees F @ max. RPM —Menthol added*

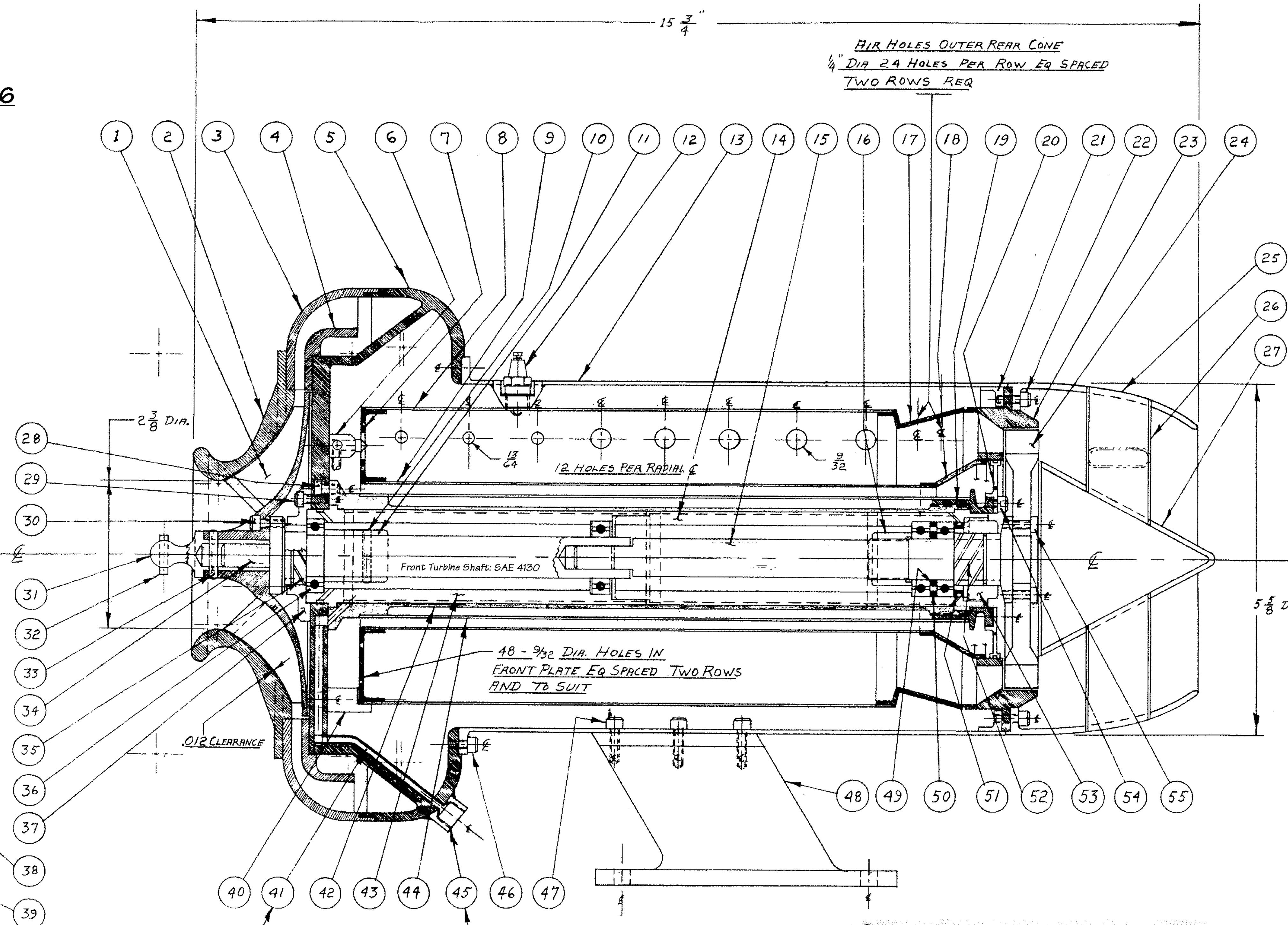
**Gasoline (White)**

| | Flame-out | Starting | Low Range | High Range |
|---|---|---|---|---|
| **RPM** | 9,000 | 8,000 to 10,000 | 9,750 | 33,000 |

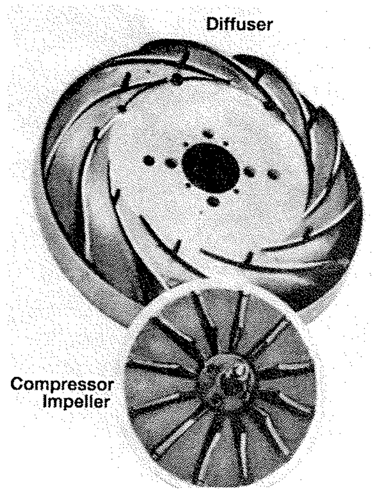
*Exhaust temperature: 1000 degrees F @ max. RPM*

**Numbers in circles refer to Bill Of Materials on page 6**





OIL RETURN LINE SHOWN
(TYPICAL) OIL + FUEL (NOT SHOWN)
Use non-detergent "spindle" oil—SAE 10



## NOTES:

### Turbine Data

Dia. 4.10 in., Width .530 in.
Press. Ratio 2:1 Vel. at P. Dia. 856 ft./sec.
Weight of gas .5 lbs/sec. Axial vel. 685 ft./sec.
Nozzle angle 22° - 16 blades - annular area 4.0 in.$^2$
Ent. Ang. of turbine 38° 30'
Exit ang. of turbine 43° 30'
Exhaust Temp. 1100° F.
Length of blade .340
No. of blades 28
Material of turbine A286
Material of nozzle 321 stainless

### Compressor Data

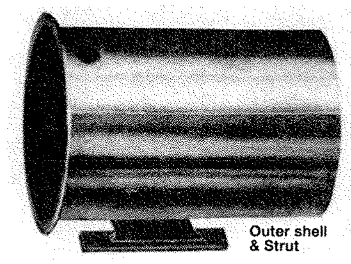
Dia. 4.750 in., Exit width .165 in. +.000, /-.003
Press. Ratio 2:1
Weight of gas inducted .5 lbs/sec.
Rev. per min. (max) 49,000

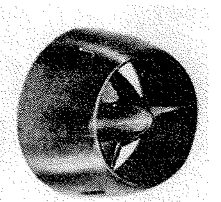
### Engine Power Output

Net 17 to 30 horsepower @ shaft
Jet thrust 15 lbs. static to 25 lbs. dynamic

Note "A" on Detail 44:
16 - 5/32" dia. air holes on each end, 11/16" from ends

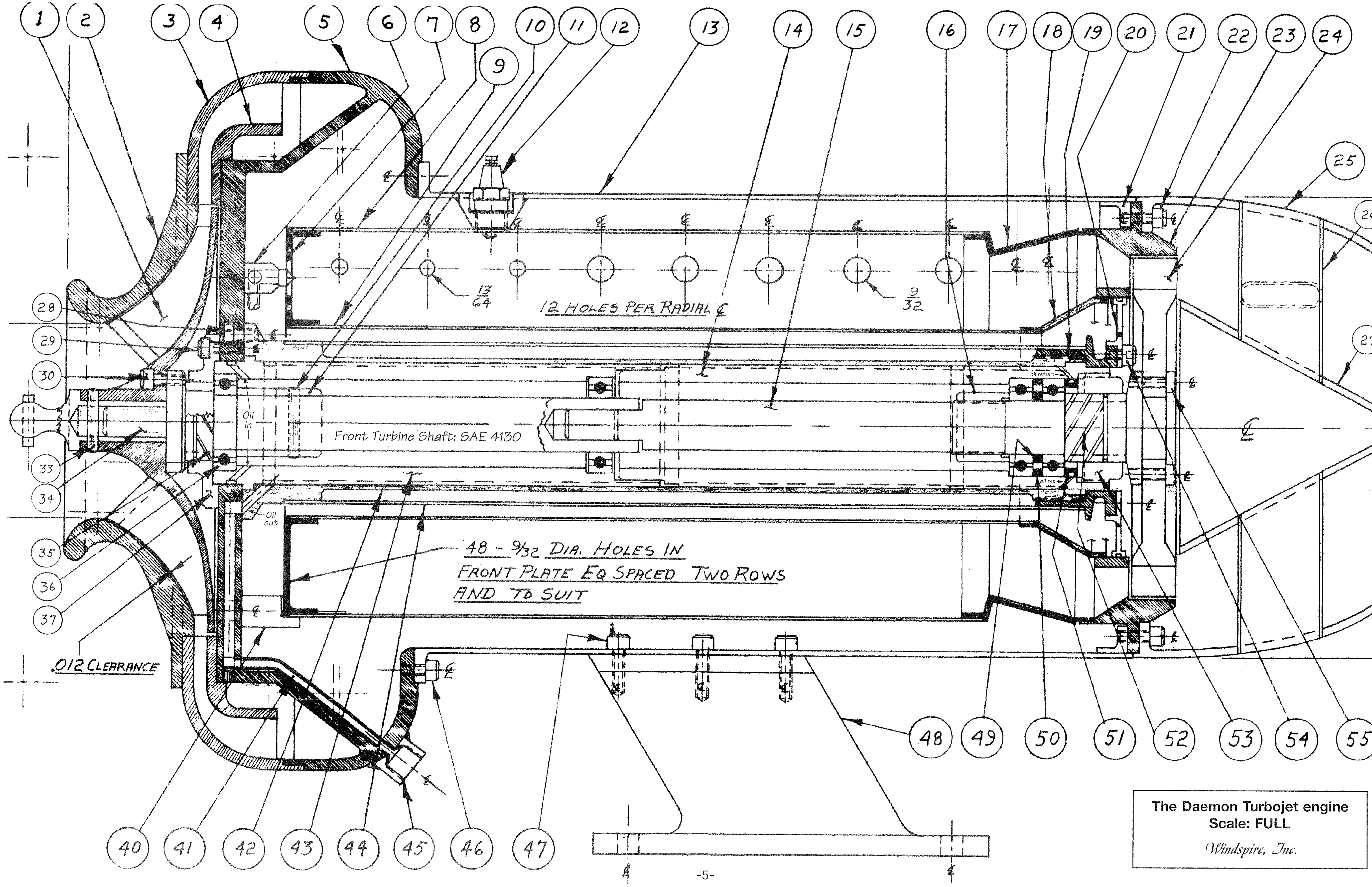
Note "B" on Detail 20:
Six .032" dia. holes near hub for turbine cooling


Outer shell & Strut

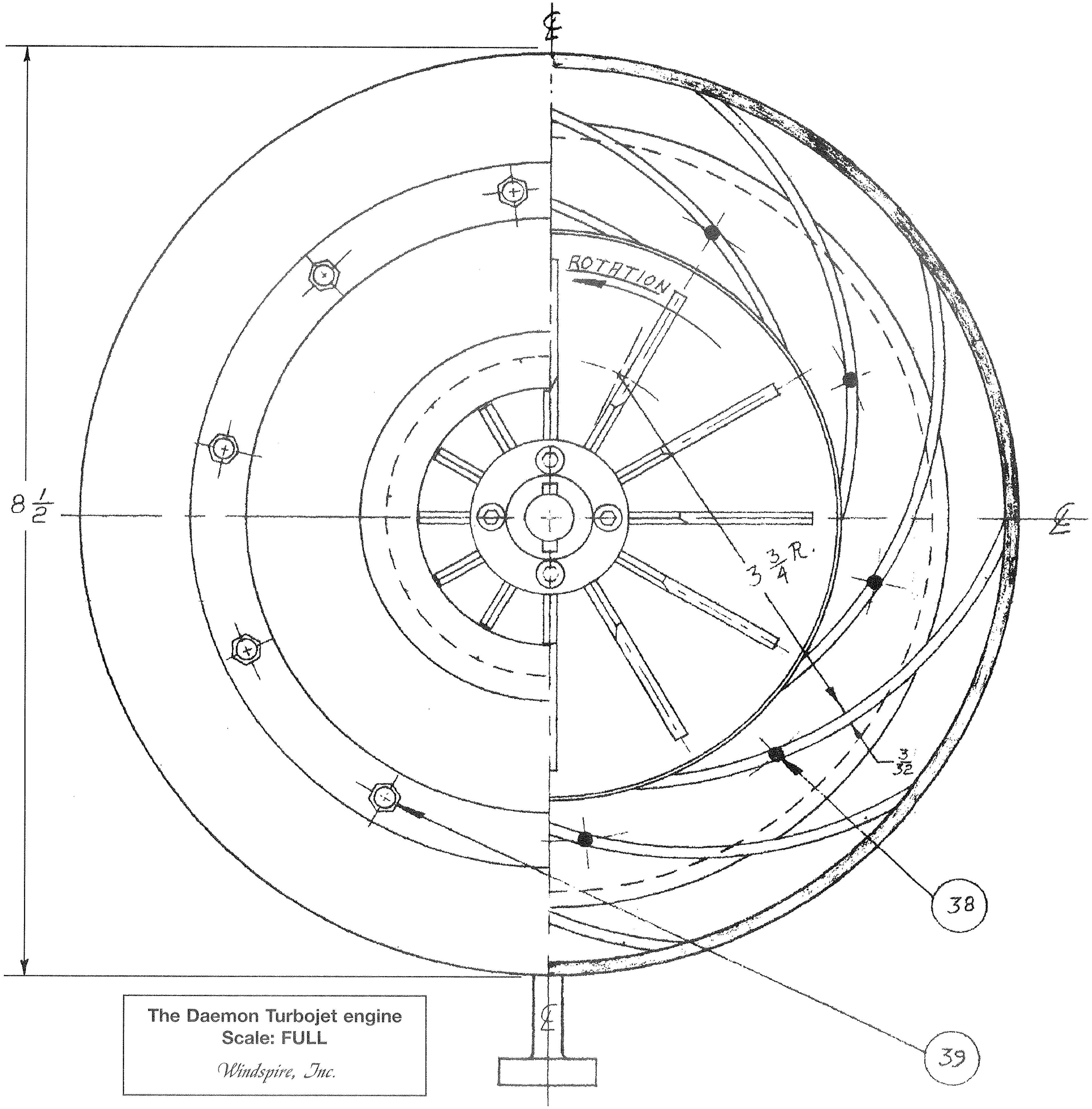

Tail cone (outer), Strut & Tail cone (inner)

The Daemon Turbojet engine
Scale: REDUCED

*Windspire, Inc.*



**The Daemon Turbojet engine**
**Scale: FULL**
*Windspire, Inc.*



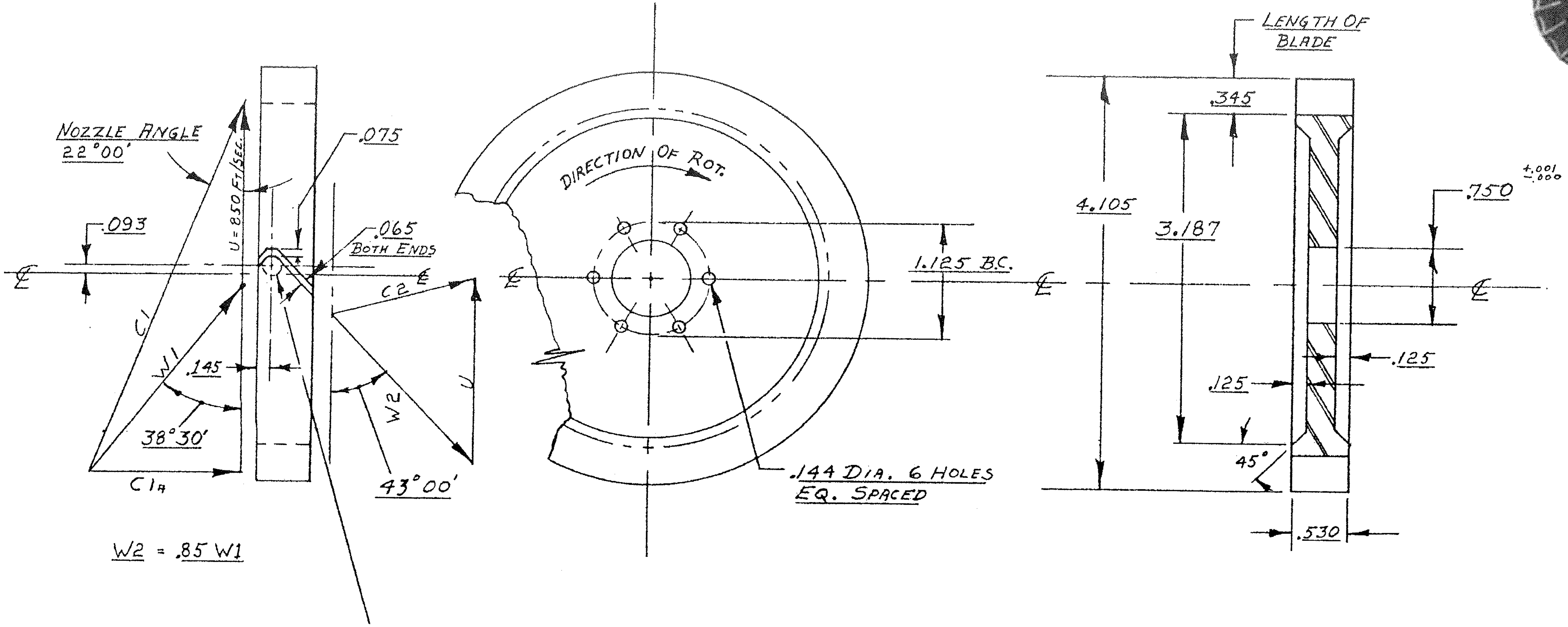
The Daemon Turbojet engine
Scale: FULL
*Windspire, Inc.*

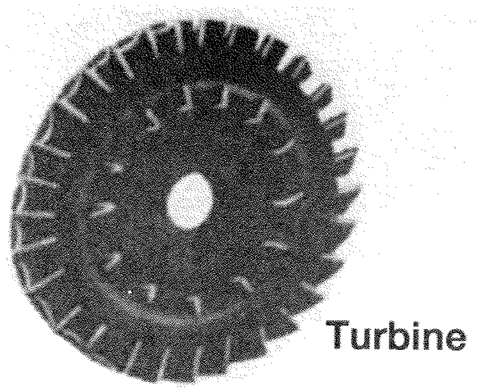
| BILL OF MATERIALS | | | |
|---|---|---|---|
| Det. No. | No. Req. | Description | Material |
| 1 | 1 | Compressor Impeller - cast (or weld. constr.) | Aluminum casting |
| 2 | 1 | Compressor Shroud - cast (or weld. constr.) | Aluminum casting |
| 3 | 1 | Diffuser Shroud - cast (or welded construc.) | Aluminum casting |
| 4 | 1 | 10 Vane Diffuser - cast (or welded constr.) | Aluminum casting |
| 5 | 1 | 5 Vane Diffuser - cast (or welded constr.) | Aluminum casting |
| 6 | 1 | Fuel Nozzle Assembly - 3 nozzles, eq. spaced | 321 Stainless steel |
| 7 | 1 | Combustion Chamber Front Plate | .062" 321 Stainless steel |
| 8 | 1 | Combustion Chamber Outer Tube | .032" 321 Stainless steel |
| 9 | 1 | Combustion Chamber Inner Tube | .032" 321 Stainless steel |
| 10 | 1 | 1/8" Diameter pin | Brass |
| 11 | 1 | Bearing Retention Bushing | Cold rolled steel |
| 12 | 1 | Spark Plug | Champion V-1 or NGK CM-6 |
| 13 | 1 | Engine Outer Shell - welded construction | .062" Cold rolled steel tubing |
| 14 | 1 | Rear Inner Spindle Bushing - machined | 2024-T4 Aluminum |
| 15 | 1 | Rear Turbine Shaft | SAE 4130 Chromoly steel |
| 16 | 1 | Threaded Bearing Retainer Nut | Cold rolled steel |
| 17 | 1 | Combustion Chamber Rear Outer Cone | .062" 321 Stainless steel |
| 18 | 1 | Combustion Chamber Rear Inner Cone | .062" 321 Stainless steel |
| 19 | 1 | Outer Spindle Nut - threaded | Cold rolled steel |
| 20 | 1 | Nozzle Plate | Cold rolled steel |
| 21 | 1 | Rear Flange - full circle (ring) | Cold rolled steel (Spot weld) |
| 22 | 12 | 6-32 X ½" - equally spaced | Socket head cap screws |
| 23 | 1 | Nozzle - welded construction | 321 Stainless steel |
| 24 | 1 | Turbine | Machine from solid A286 |
| 25 | 1 | Tail Cone Outer - cast or spun to shape | 316 Stainless steel (.093" Wall) |
| 26 | 3 | Strut - ¾" dia. tube elongate - cast or weld. | 321 Stainless steel |
| 27 | 1 | Tail Cone Inner - cast (or welded construc.) | 316 Stainless steel casting |
| 28 | 6 | 8-32 X 3/8" | Socket head cap screws |
| 29 | 4 | 6-32 X 3/8" | Socket head cap screws |
| 30 | 4 | 6-32 X 3/8" | Socket head cap screws |
| 31 | 1 | Power Take Off | Tool steel, hardened |
| 32 | 1 | 1/8" Diameter pin | Drill rod, hardened |
| 33 | 1 | 1/8" Diameter pin | Brass |
| 34 | 1 | Compressor Shaft | SAE 4130 |
| 35 | 1 | Spiral Oil Seal (Front) | Thin wall cold rolled steel bushing |
| 36 | 4 | Fafnir Bearing | No. M9303K (or equivalent) |
| 37 | 1 | Front Bearing Retainer | 2024-T4 Aluminum |
| 38 | 10 | 6-32 X 1" | Socket head cap screws |
| 39 | 10 | 6-32 | Nickel plated brass cap nut |
| 40 | 3 | Front Burner Supports - 3 equally spaced | 3/8" diameter Cold rolled steel |
| 41 | 3 | 1/8 I.D. Tubing - length to suit | Copper (or Cold rolled steel) |
| 42 | 1 | Outer Spindle Housing | Cold rolled steel |
| 43 | 1 | Front Inner Spindle Bushing - machined | 2024-T4 Aluminum |
| 44 | 1 | Outer Spindle Tube | 321 Stainless steel |
| 45 | 2 | Boss - housing for oil supply/oil return ports | 2024-T4 Aluminum |
| 46 | 1 | 6-32 X 3/8" | Socket head cap screws |
| 47 | 3 | 6-32 X 3/8" | Socket head cap screws |
| 48 | 1 | Strut - machined to I-Beam shape | 1" X 2½" X 5" 2024-T4 Aluminum |
| 49 | 1 | Inner Bearing Spacer | Cold rolled steel |
| 50 | 1 | Outer Bearing Spacer | Cold rolled steel |
| 51 | 1 | Outer Spacer with Oil Return Holes | Cold rolled steel |
| 52 | 1 | Spiral Oil Seal (Rear) | Thin wall cold rolled steel bushing |
| 53 | 1 | Spindle Retainer Nut - threaded | Brass |
| 54 | 6 | 6-32 X ¼" | Socket head cap screws |
| 55 | 6 | 6-32 X ½" | Socket head cap screws |

## Composition & Properties of A286

Iron 50% Nickel 25% Chromium 14%
Titanium 2% Aluminum 1% Vanadium <1%

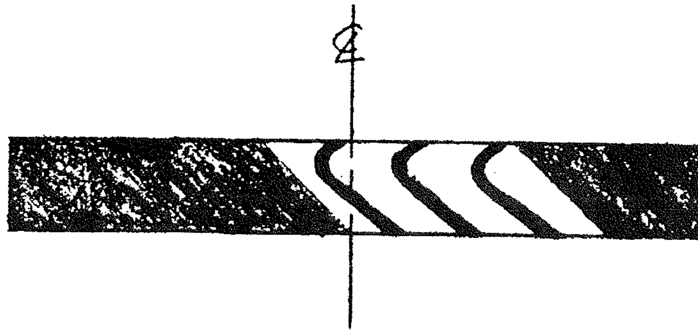
An austenitic alloy with moderate strength and rupture characteristics to 1300°F, and good oxidation resistance to 1500°F. AMS 5525 limits tensile strength to 105,000 psi maximum in all gauges. The 1800°F solution treatment is designed to yield best possible forming characteristics with an optimum compromise between strength and creep rupture properties after aging. Used in many moderate temperature and stress applications in jet engines such as low pressure turbines, compressors, and tailcones.





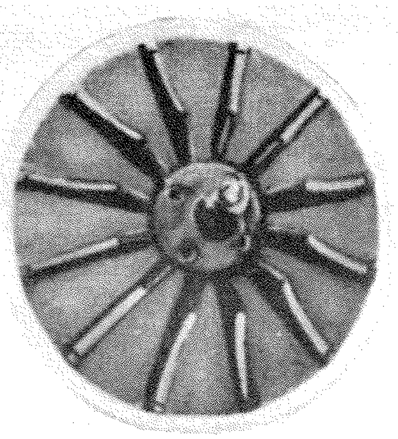
BLADES ARE MACHINED WITH
.187 DIA. END MILL ONCE PROPER
SETTING IS MADE NO MOVEMENT
OF END MILL IS PERMITTED EXCEPT
WHEN MOVING OVER TO MACHINE
.065 THICKNESS OF BLADE
END MILL IS SET TO MACHINE
FULL LENGTH OF BLADE ALSO END
MILL SHOULD HAVE .020-.030 RADIUS
NO SHARP CORNERS AT BOTTOM
OF BLADE

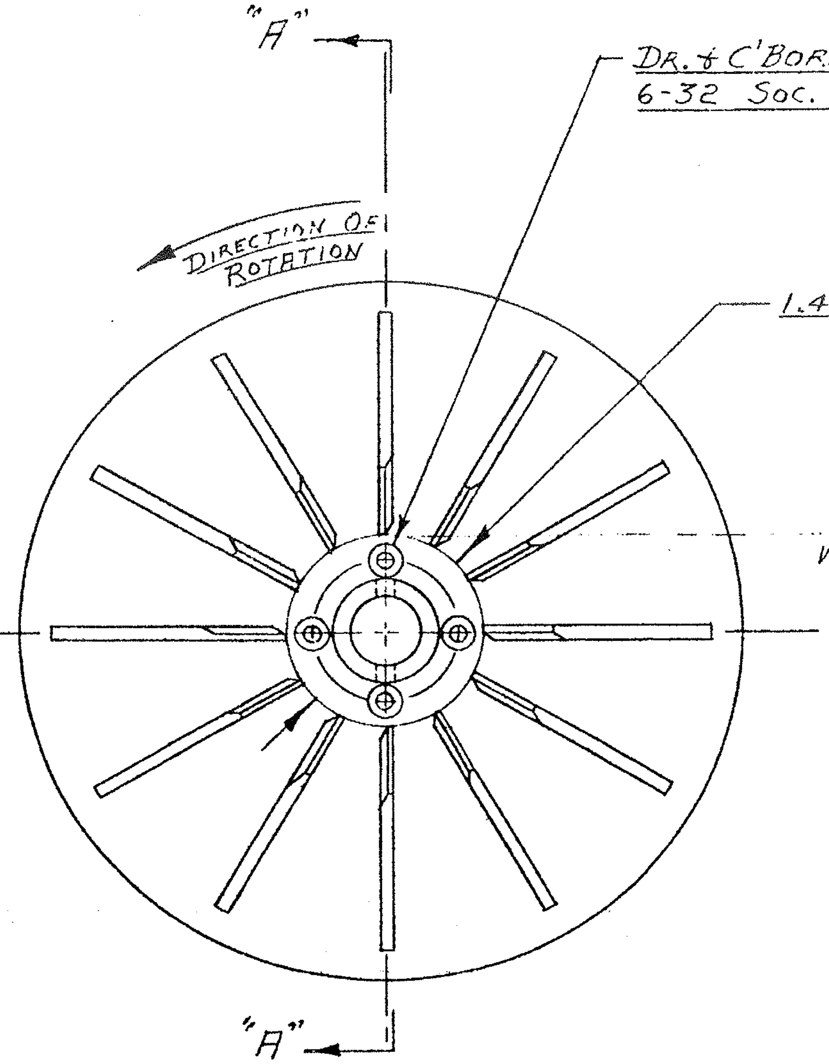
㉔ TURBINE (IMPULSE) ONE REQUIRED
NO. OF BLADES. 28
ANNULAR AREA 3.9 $IN^2$
PRESS. RATIO 2-1
WT. OF GAS 0.5 LBS/SEC
MATERIAL: "UNIVERSAL CYCLOPS"
(A 286 OR 1753)
HEAT TREAT PER MFG. SPEC.
BALANCE TURBINE: MAX. OUT BALANCE
.005 GRAM AT OUT SIDE DIA.
(STATIC BALANCE ONLY)

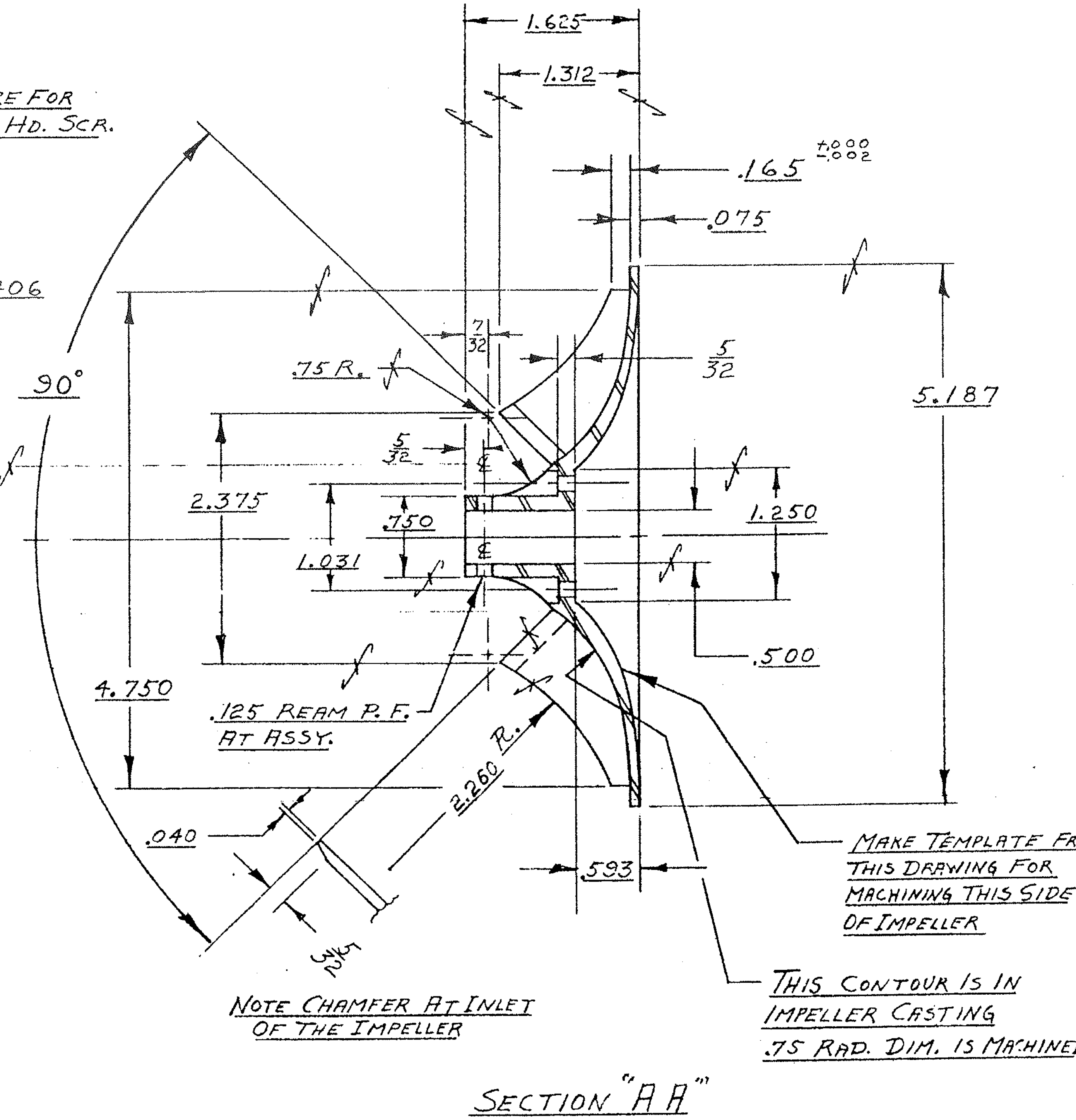


BLADE IMPRESSIONS PRINTED BY
ROLLING TURBINE DIA. OVER DRAWI
BOTTOM VIEW IMPRESSION. + (THICKNESS
DUE TO INK + ROLLING IS OVERSIZE)

The Daemon Turbojet engine
Scale: REDUCED
*Windspire, Inc.*

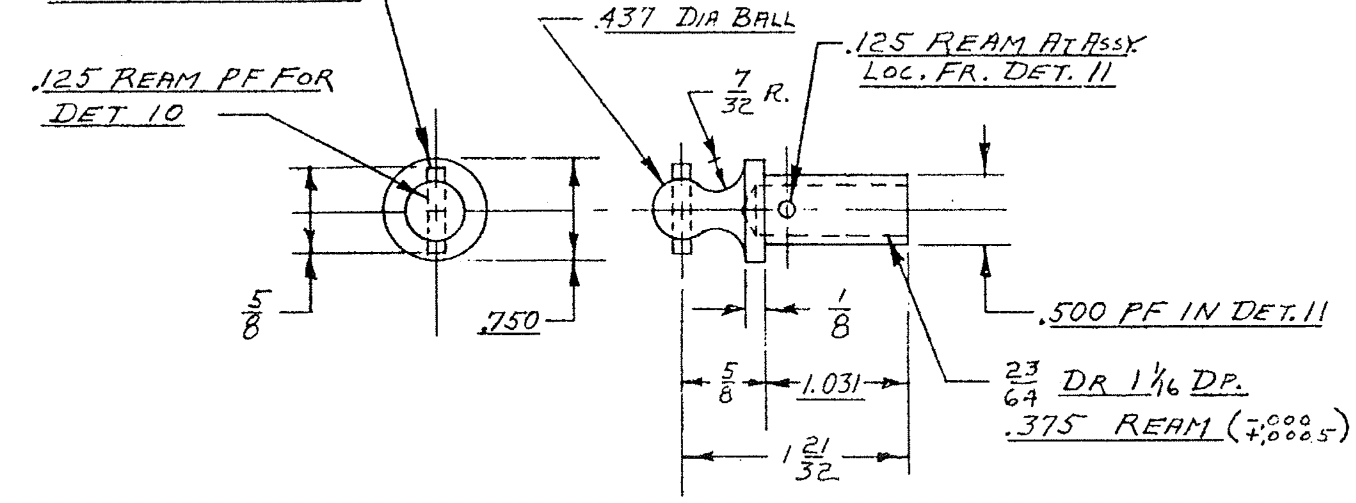

Compressor Impeller





## SECTION "A A"

(10) 1/8 DIA DR. ROD
HARDEN & DRAW
ROCK. "C" 54-56

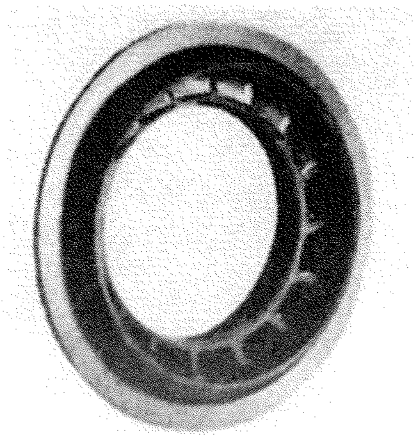


(31) UNIVERSAL BALL COUPLER ONE REQ
MATERIAL D.R. HDN. & DRAW ROCK. "C" 54-56

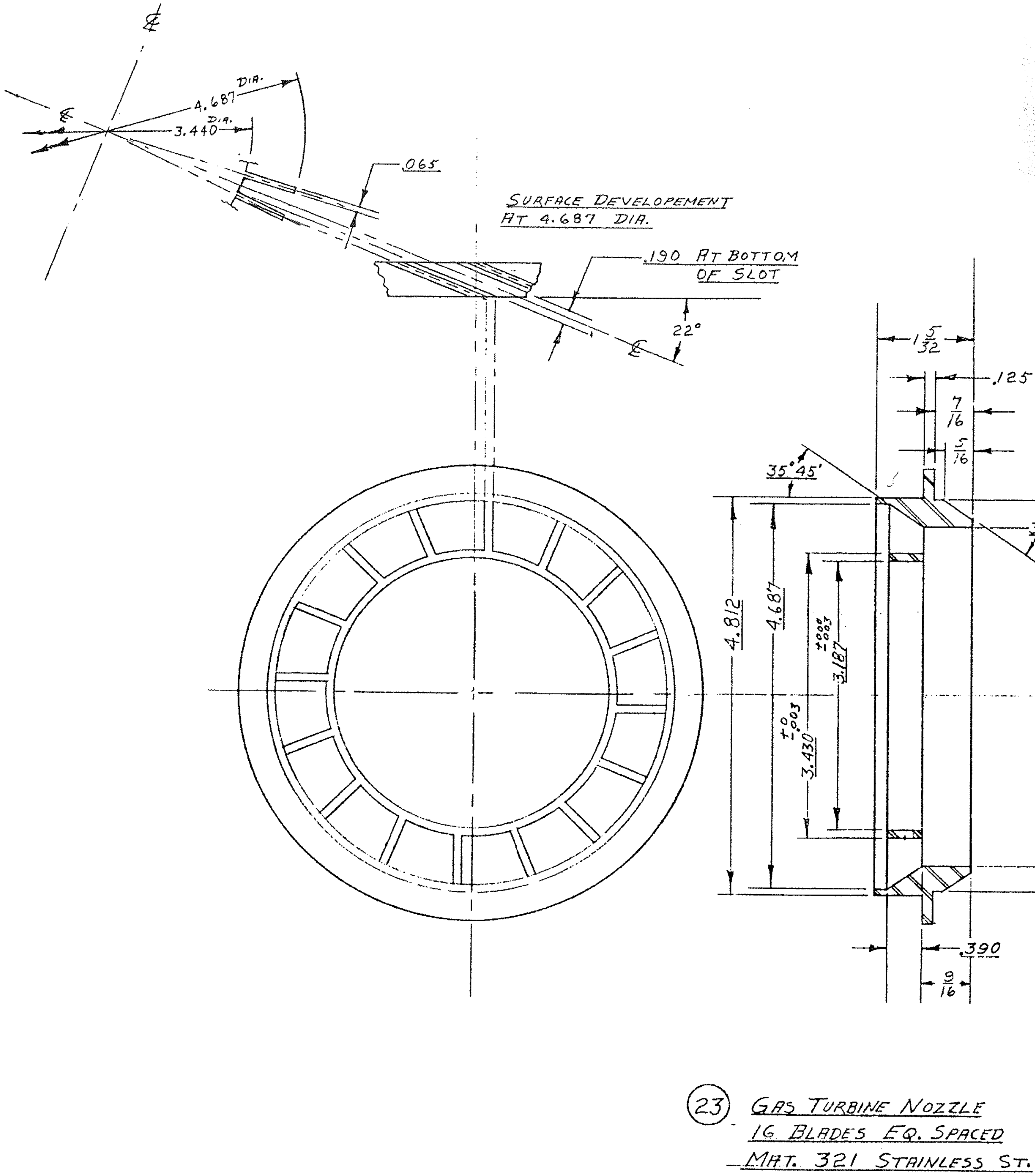
(1) COMPRESSOR IMPELLER ONE REQ.
MAT. ALUM ALLOY (356-T6) CASTING

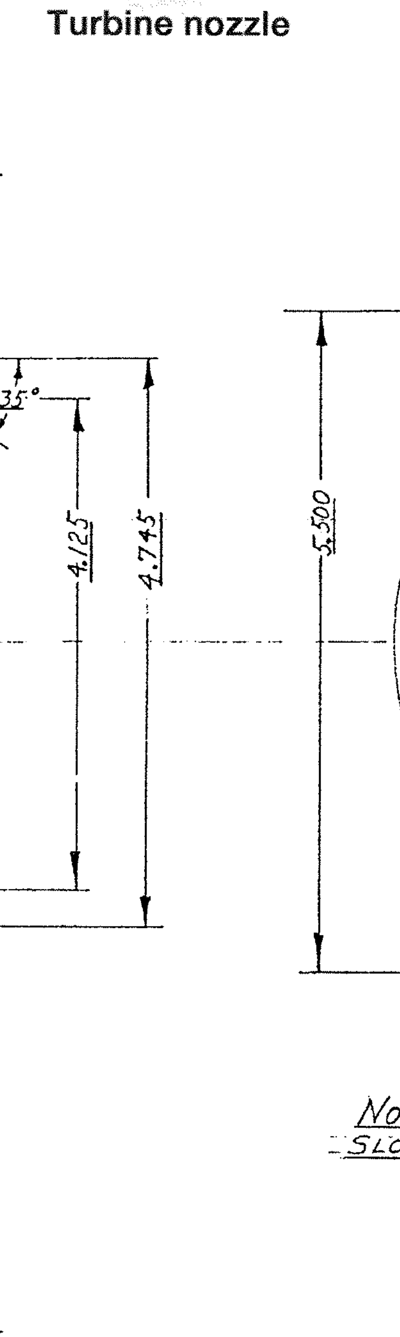
"STATIC BALANCE": MOUNT ON BAL. SHAFT
USING HARDEN & GROUND KNIFE EDGES
PERFECTLY HORIZONAL AND 60 CYCLE
VIBRATOR ; BALANCE FOR ZERO
DISPLACEMENT

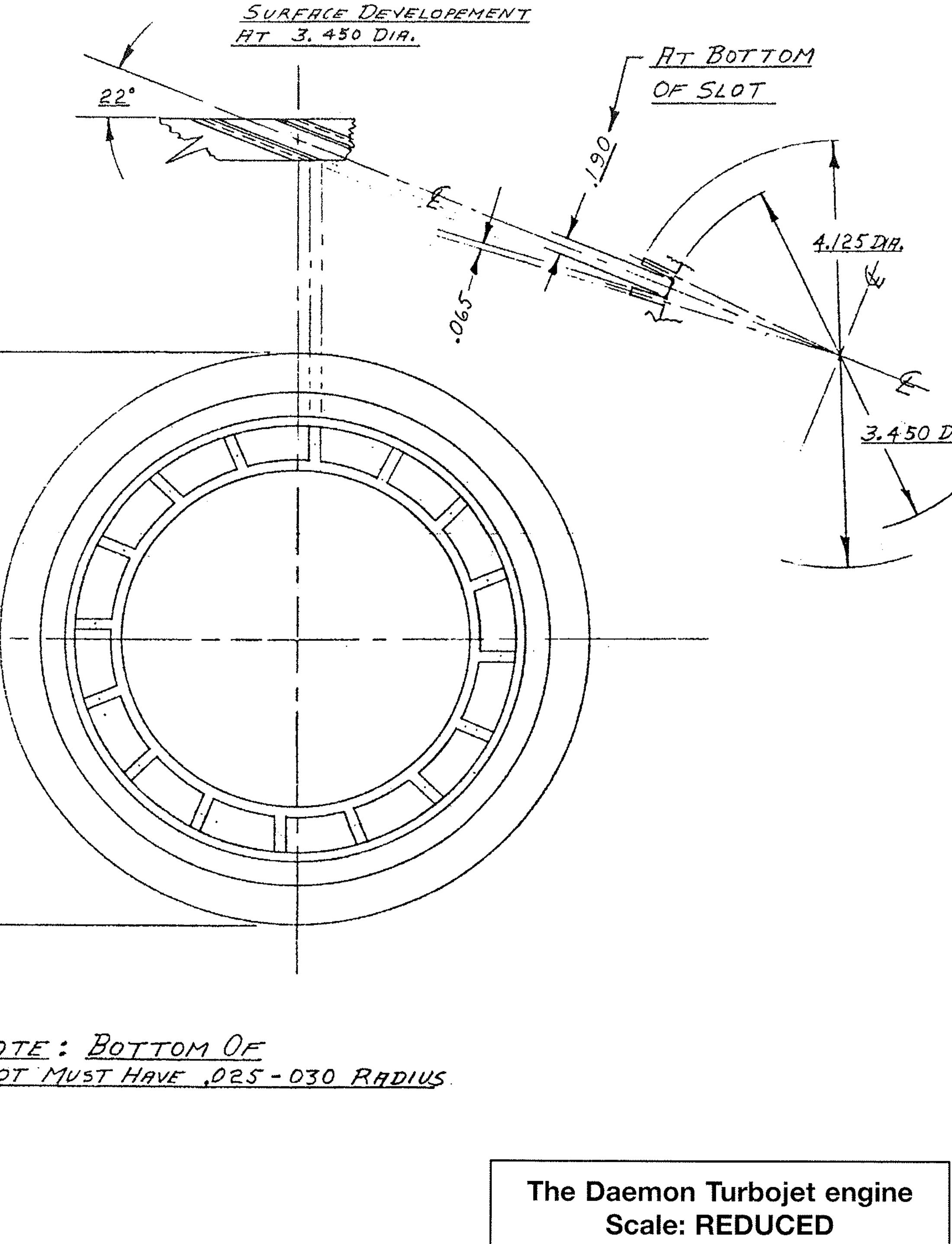
**The Daemon Turbojet engine**
**Scale: REDUCED**
*Windspire, Inc.*



Turbine nozzle





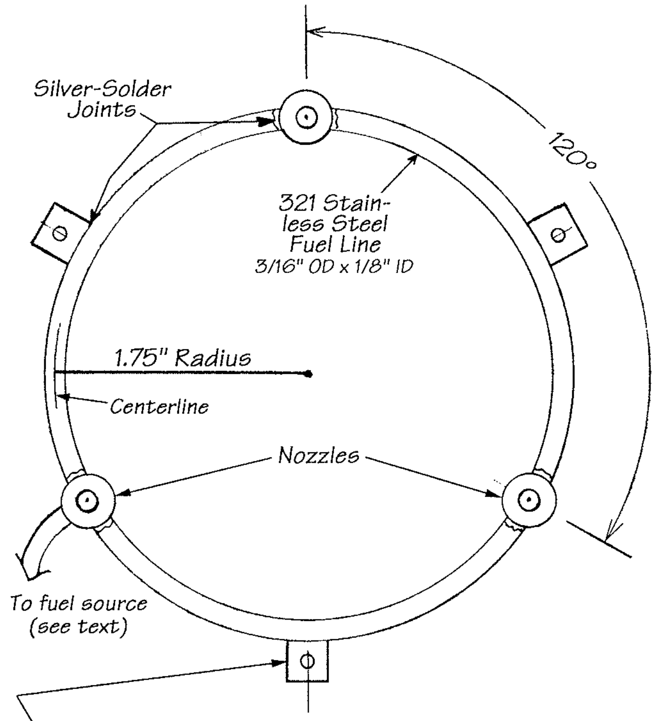

SURFACE DEVELOPEMENT AT 3.450 DIA.
AT BOTTOM OF SLOT
22°
.190
.065
4.125 DIA.
℄
3.450 D
NOTE: BOTTOM OF SLOT MUST HAVE .025-030 RADIUS

**The Daemon Turbojet engine**
**Scale: REDUCED**
*Windspire, Inc.*

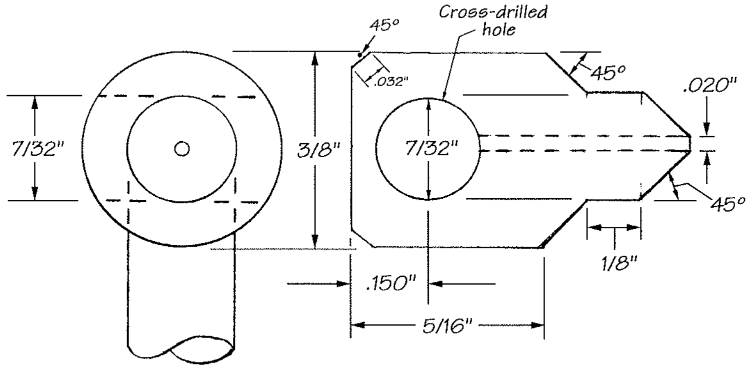
## ADDITIONAL CONSTRUCTION DETAILS AND CLARIFICATIONS

Before attempting to build *The Daemon,* it is important to take time and study all the accompanying drawings, text and Bill Of Materials. Dimensions not supplied may be scaled from the full-size, cutaway drawings on pages 5 and 6. If anything remains unclear, take these prints to an experienced machinist, who will be able to properly interpret the details of construction. Below are additonal construction notes.

1. Fuel Nozzle assembly details are illustrated below. Only one of the 3 Nozzles has an additional 7/32" hole drilled, as shown, for incoming fuel line. The fuel line that feeds the ring of 3 Nozzles begins as a #3 bulkhead-type fitting mounted to the engine's Outer Shell. The entire Fuel Nozzle Ring is mounted to the back of the 5 Vane Diffuser (part #5) with three #6 socket head cap screws via the mounting tabs.


Silver-Solder Joints
120°
321 Stainless Steel Fuel Line 3/16" OD x 1/8" ID
1.75" Radius
Centerline
Nozzles
To fuel source (see text)

*3/8" wide X 1/2" high nozzle-ring mounting tabs are cenered between nozzles and silver-soldered to fuel line after nozzles are assembled. A .130" hole is drilled in mounting tabs as shown. Ring is bolted to rear diffuser (#5), which is drilled and tapped for #6 mounting screws.*



*3/16" OD X 1/8" ID main fuel line attaches to only one of the 3 nozzles. Drill 7/32" vertical hole in nozzle. Fuel line is silver-soldered to hole.*

***Above left:*** **The complete Fuel Nozzle Ring, which distributes fuel via 3 Nozzles into the Combustion Chamber for ignition.**

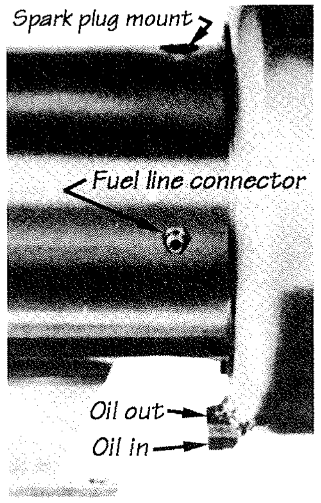
***Above right:*** **Detailed construction of the Nozzle head, through which fuel is sprayed into the Combustion Chamber. As indicated, only one of the 3 Nozzles has a 3rd hole for the incoming fuel.**

2. The photo at the right illustrates the general arrangements of the ports for fuel and oil, plus the Spark Plug mount.

The Oil In and Oil Out ports are compression fittings set within aluminum bosses welded to the bottom of the 5 Vane Diffuser (#5). The in and out ports are separated by approximately 2".

The fuel enters the Fuel Nozzle Ring via the fuel line connector mounted on the side of the engine's Outer Shell. This fitting is a #3 bulkhead-type union connector.

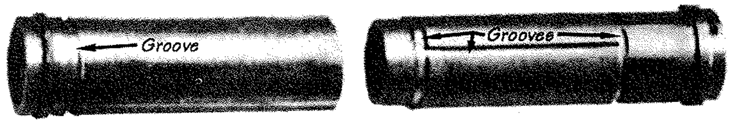
A Champion *V-1* or NGK *CM-6* Spark Plug screws into a steel boss countersunk and welded to the top of the engine. The boss is about 1/4" thick.



3. From the oil-in port mounted to the bottom of the 5 Vane Diffuser, oil flows to a groove (about 1/16" wide X 1/32" deep) machined around the circumference of the flange surrounding the front of the Front Inner Spindle Bushing (part #43), into six 1/16" equally spaced 45° holes drilled through that flange (shown on page 5), and through the inside of the Front and Rear Inner Spindle Bushings, thus providing oil to the front, middle and rear bearings. The oil flow then returns via six 1/16" equally spaced 45° holes drilled in the Outer Spacer With Oil Return Holes (part #51), to the groove around the circumference of that Spacer, through 1/16" holes drilled in the rear flange of the Rear Inner Spindle Bushing, and, via vertical and horizontal grooves of about 3/16" wide X 1/16" deep (see illustration below), the oil flow continues toward the front of the engine and to the 45°, 3/16" oil-out hole drilled in the flange around the front of the Outer Spindle Housing (part #42); it is then routed, as illustrated on page 5, to the compression fitting set within the oil-return Boss at the bottom of the Diffuser. Note that a second horizontal groove should be machined into the Front and Rear Inner Spindle Bushings 180° from the one shown below (visible in the rear Bushing on the right).

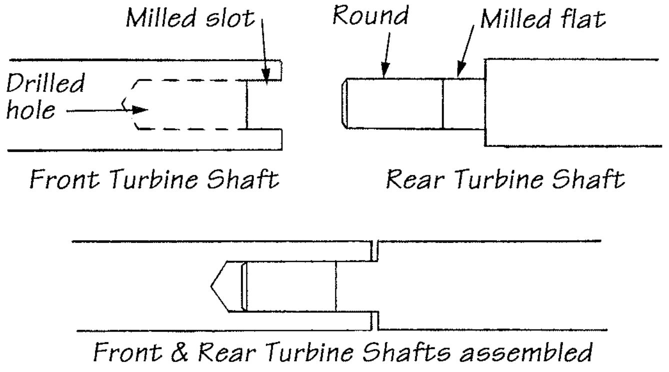
Carefully study drawings and photos of parts.

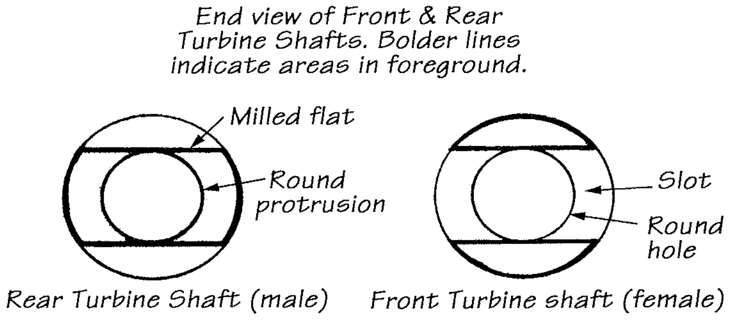
A low-volume oil pump with 3 to 5 lbs. of pressure supplies the oil at just a few drops a minute. Experimentation will determine proper pressure and flow. If the oil flow to the bearings seems inadequate, enlarge the various oil-flow holes by about 1/64". Use a non-detergent "spindle" oil (e.g., SAE 10).



4. The Front and Rear Spiral Oil Seal Bushings (parts #35 and 52) are machined with about 4 grooves per inch. The grooves are .032" wide X .032" deep. The front Seal has a right-hand helix and the rear has a left-hand helix.

5. The Front and Rear Turbine Shafts are interconnected as illustrated below, with a small gap between the two sections to allow for heat expansion.




End view of Front & Rear Turbine Shafts. Bolder lines indicate areas in foreground.
Milled flat
Round protrusion
Slot
Round hole
Rear Turbine Shaft (male)
Front Turbine shaft (female)

6. The Front Bearing Retainer (part #37) is custom sized for .0025" top and bottom (.005" total) clearance between its inside diameter and the outside diameter of the Front Spiral Oil Seal.

7. The Inner and Outer Bearing Spacers (parts #49 & 50) must be matched. They are custom fit for zero clearance.

# MATERIAL SUPPLIERS

*Also see the list of suppliers in Windspire's* Homebuilt Jet Engine Handbook

## METALS:

**Shapiro Supply Company — *supplier of most metals***
Natural Bridge Avenue, St. Louis, MO 63120 USA
Tel: 800-833-1259 or 314/382 7000 • Fax: 314-382-8557
E-Mail shapiro@stlnet.com
Web: http://www.shapirosupply.com/

**Diversified Metals — *supplier of A286 & other metals***
2534 Midway Avenue, Shreveport, LA 71108 USA
Tel: 800-828-8621 or 318-635-5500 • Fax: 318-635-8800
E-mail: divmet@shreve.net
Web: http://www.metalsdistributor.com/

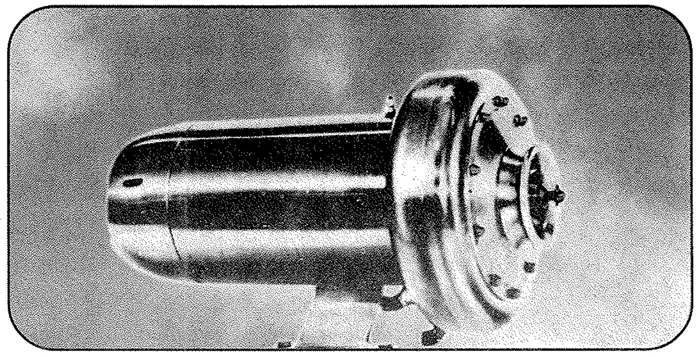
**Ulbrich Stainless Steels & Special Metals, Inc. — *supplier of A286 & other metals***
57 Dodge Avenue, North Haven, CT 06473-1191 USA
Tel: 800-243-1676 or 203-239-4481 • Fax: 203-239-7479
E-mail: ulbrich@ulbrich.com
Web: http://www.ulbrich.com/home.html

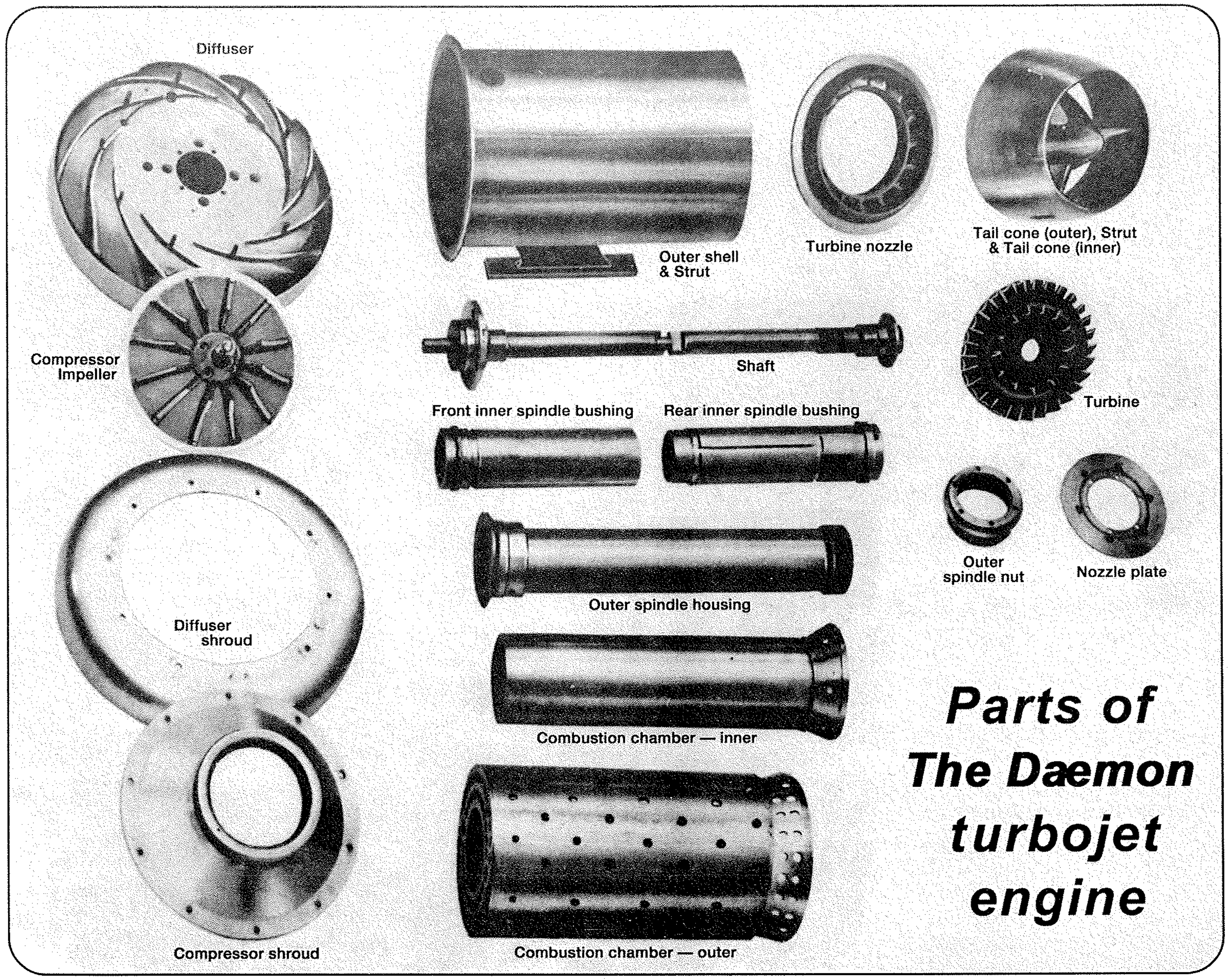
**High Temp Metals, Inc. — *supplier of A286 & other metals***
12910 San Fernando Road, Sylmar, CA 91342-3601 USA
Tel: 800-500-2141 or 818-362-5357 • Fax: 818-362-9884
E-mail: sales@hightempmetals.com
Web: http://www.hightempmetals.com/index.html

**Falcon Metals Worldwide — *supplier of A286 & other metals***
39 Hewson Avenue, Waldwick, NJ 07463 USA
Tel: USA 800-631-0728; NJ 201-670-8300; CANADA 800-544-5501 • Fax: 201-670-0033
E-mail: query@falcon-metals.com
Web: http://www.falcon-metals.com/

## BEARINGS:

**The Torrington Company — *manufacturer & supplier of Fafnir bearings***
59 Field Street, P.O. Box 1008, Torrington, CT 06790-1008 USA
Tel: 860-626-2623 • Fax: 860-496-3625
Web: http://www.torrington.com/products/fafnir/





**Parts of The Dæmon turbojet engine**

### NOTICE

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